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UTILITY PATENT APPLICATION TRANSMITTAL <small>(Only for new nonprovisional applications under 37 C.F.R. § 1.53(b))</small>	Attorney Docket No.	BFGHP0265US
	First Inventor or Application Identifier	K. C. Schramm
	Title	AIRCRAFT HEATED FLOOR PANEL
	Express Mail Label No.	EK608630732US

APPLICATION ELEMENTS <small>See MPEP chapter 600 concerning utility patent application contents.</small>	ADDRESS TO: Assistant Commissioner for Patents Box Patent Application Washington, DC 20231
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Docket No.: BFGHP0265US
Applicant: Kevin Christopher Schramm
Title: AIRCRAFT HEATED FLOOR PANEL

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AIRCRAFT HEATED FLOOR PANEL

FIELD OF THE INVENTION

This invention relates generally to an aircraft heater floor panel and, more particularly, to an aircraft floor panel including a plurality of layers cured to form a lower support level, an upper heater level, and a top metal sheet for protecting the underlying layers from floor-traffic related damage.

BACKGROUND OF THE INVENTION

An aircraft will commonly include heated floor panels in order to maintain the cabin at a comfortable temperature. The floor panel is typically supported by an aircraft structure and has a structural integrity sufficient to support the weight of people and objects resting on top thereof. A metal face sheet typically forms the top surface of the panel to protect the underlying layers from punctures from high heels, chips from dropped objects, scratches from dragged luggage and/or other floor-traffic related hazards.

An aircraft heated floor panel is usually made by compiling a series of layers together to form a lower support level and an upper heater level. The lower support level may include, for example, a honeycomb layer surrounded by reinforcing fiber layers. The upper heater level may include, for example, a resistance element disposed in layers of a thermosettable dielectric material. High temperature film adhesives and scrim are appropriately provided between the layers and the compiled layers are cured at an elevated temperature (often in excess of about 250° F) to form a composite structure.

The composite structure is then cooled to room temperature and the metal face sheet is secured to the previously cured layers in a separate manufacturing step. Specifically, for example, an epoxy cross-link adhesive may be used to bond the metal face sheet to the top of the heater. The secured metal face sheet may then be cut/trimmed to the correct size and an appropriate surface treatment (e.g., paint, primer, anodizing, etc.) may be applied.

SUMMARY OF THE INVENTION

The present invention provides an aircraft heated floor panel wherein the metal face sheet may be secured to the underlying composite structure during a high temperature curing step. In the past, this was not possible due to the differences in the thermal expansion rates between the support/heater layers and the metal layer. Specifically, at the high temperatures necessary to cure the support/heater layers, the metal face sheet would expand outwardly at a greater rate than the support/heater layers. If a high temperature film adhesive was used to secure the metal face sheet to the underlying support/heater layers, such an adhesive would lock the metal face sheet in this expanded condition. As the panel was subsequently cooled to room temperature, the bonded metal face sheet would attempt to contract inwardly thereby causing gross warping of the sheet.

More particularly, the present invention provides an aircraft floor panel comprising a plurality of layers cured together to form a lower support level and an upper heater level, a metal face sheet for protecting the top of the panel from floor-traffic related damage, and a pressure sensitive adhesive bonding the metal face sheet to the underlying support/heater layers. The support/heater layers together have a certain rate of thermal expansion and the face sheet has a different rate of thermal expansion. The pressure sensitive adhesive (or other adhesive which retains elasticity after bonding allows the different rates of thermal expansion to be accommodated during the curing and cooling steps of the manufacturing process.

In a method of making an aircraft heated floor panel according to the present invention, a layer of the adhesive is applied to the top of the heater level and the face sheet is placed thereon. The support/heater layers and the metal face sheet are then cured at an elevated curing temperature to form a composite structure whereby the face sheet expands at a different rate than the support/heater layers. When the composite structure is subsequently cooled to room temperature, the retained elasticity of the adhesive layer allows the face

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1. **Introduction**

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dropped objects, scratches from dragged luggage and/or other floor-traffic related hazards. As is explained in more detail below, the design of the floor panel 10 eliminates the need for a separate bonding step for the metal face sheet 16 and/or the need to perform this step at room temperature.

5 Referring now additionally to Figure 2, the underlying layers 18 of the panel 10 form a lower support level 20 and an upper heater level 22. The support level 20 may be formed from a honeycomb layer 24 (e.g., aramid) sandwiched between fiber layers 26 (e.g. carbon fiber prepreg) and fiber layers 28 (e.g., fiberglass epoxy prepreg). Additional and different support layers which
10 provide the sufficient stiffness, satisfy the thickness limitations, and accommodate weight considerations may be used.

The heater level 22 may be an electrothermal heater, that is it may comprise an electrically resistive element electrically isolated in a dielectric. The element may be an etched foil type element or a wire and/or the element may be
15 configured in a zig-zag type arrangement. The element may be isolated by encapsulation by disposing it between plies of an appropriate curable material such as thermoset plastic or any other dielectric or electrically non-conductive material. For example, the plies may be made of a polyamide film, such as Kapton® available from the E.I. DuPont DeNeumours Company.

20 The underlying layers 18 may include an adhesive layer 30 between the support level 20 and the heater level 22. The adhesive may be a film adhesive (e.g., epoxy) and should be capable of withstanding elevated curing temperatures so that, during the curing process, the layer 30 will facilitate the bonding of the support level 20 to the heater level 22. The adhesive layer 30
25 may incorporate a scrim if necessary or desired for better distribution of the adhesive.

The floor panel 10 includes an adhesive layer 32 between the underlying layers 18 and the metal face sheet 16. According to the present invention, this adhesive layer 32 is an adhesive which retains elasticity after bonding,
30 specifically a pressure sensitive adhesive (PSA) which is activated by the

application of pressure and which performs appropriately during elevated curing temperatures. Suitable pressure sensitive adhesives include acrylic pressure sensitive adhesives (e.g., catalog number F-9473PC available from Minnesota Mining and Manufacturing Company, St. Paul, Minnesota, USA.) Primers may be used to enhance the bonding characteristics of the adhesive.

A method of making the floor panel 10 according to the present invention is schematically shown in Figures 3A-3F. Initially, the layers 18 of the lower support level 20 and the upper heater level 22 are compiled. (Figure 3A.) The pressure sensitive adhesive layer 32 is then applied to the top surface (Figure 3B) and the metal face sheet 16 placed on top of the layer 32 (Figure 3C). The support/heater layers 18 are then subjected to a curing process at an elevated temperature (e.g., in excess of about 250° F) and, at the same time, pressure may be applied to activate the pressure sensitive adhesive layer 32. (Figure 3D.) During the heat curing, the metal face plate 16 expands outwardly due to the differences in the thermal expansion rates between the support/heater layers 18 and the metal sheet 16. (Figure 3E.) As the panel 10 is subsequently cooled to room temperature (e.g., heat is removed and the panel is allowed to cool), the retained elasticity of the adhesive layer 32 allows the bonded metal face sheet 16 to contract inwardly without warping. (Figure 3F.)

Additional manufacturing steps can be streamlined as well. For example, the metal face sheet 16 can be cut to a net shape and treated with the appropriate surface treatment and then bonded to the other layers 18 in one step.

Because pressure sensitive adhesives retain elasticity after bonding, the metal face sheet 16 is allowed to contract inwardly as the panel 10 is cooled to room temperature. Additionally, the thickness of the pressure sensitive adhesive layer 32 may be varied to accommodate different curing temperatures.

Generally, the greater the thickness, the higher curing temperature that may be used. For example, a thickness of 0.010 inch would correspond to a curing temperature of about 280°F.

One may now appreciate that the use of the elastic bonding layer 32 between the metal face sheet 16 and the support/heater layers 18 allows co-curing of the respective materials notwithstanding their differing coefficients of thermal expansion. This eliminates the need for a separate bonding step for the metal face sheet 16 and/or the need to perform this step at room temperature.

Although the invention has been shown and described with respect to certain preferred embodiments, it is obvious that equivalent and obvious alterations and modifications will occur to others skilled in the art upon the reading and understanding of this specification. The present invention includes all such alterations and modifications and is limited only by the scope of the following claims.

CLAIMS

1. An aircraft heated floor panel, comprising:
a plurality of layers cured together to form a lower support level and an upper heater level;
5 a metal face sheet for protecting the top of the panel from floor-traffic related damage; and
a pressure sensitive adhesive bonding the metal face sheet to the underlying support/heater layers.
- 10 2. An aircraft heated floor panel as set forth in claim 1, wherein the support layer includes a honeycomb layer sandwiched between fiber layers.
3. An aircraft heated floor panel as set forth in claim 1, wherein the heater level comprises a resistive element encapsulated in cured thermoset plastic plies.
- 15 4. An aircraft heated floor panel as set forth in claim 1, wherein the metal face sheet is made of a metal selected from aluminum, titanium, steel, or stainless steel.
- 20 5. An aircraft heated floor panel as set forth in claim 1, wherein the support layer includes a honeycomb layer sandwiched between fiber layers, the heater level comprises a resistive element encapsulated in cured thermoset plastic plies, and the metal face sheet is made of aluminum.
6. An aircraft heated floor panel as set forth in claim 1, wherein the underlying support/heater layers include a high temperature curing adhesive layer between the support level and the heater level.

7. An aircraft heated floor panel as set forth in claim 1, wherein the pressure sensitive adhesive is an acrylic pressure sensitive adhesive.

8. An aircraft heated floor panel as set forth in claim 1, wherein the pressure sensitive adhesive is a rubber pressure sensitive adhesive.

5 9. An aircraft heated floor panel as set forth in claim 1, further comprising a primer to enhance the bonding characteristics of the adhesive.

10. In combination, an aircraft and the aircraft heated floor panel of claim 1, wherein the perimeter of the lower support level is supported by a structure of the aircraft.

10 11. A method of making the aircraft heated floor panel of claim 1, said method comprising the steps of:
applying a layer of the pressure sensitive adhesive to the top of the heater level,
placing the metal face sheet on top of the adhesive layer,
15 curing the support/heater layers and the metal face sheet at an elevated curing temperature, and
cooling the cured layers and the metal face sheet to an ambient temperature;
wherein the pressure sensitive adhesive layer allows the metal face sheet
20 to expand and contract at a different thermal expansion rate than the support/heater layers during the curing and cooling steps.

12. A method as forth in claim 11, wherein the curing temperature is at least about 250° F.

13. A method as set forth in claim 11, wherein the layer of the pressure sensitive adhesive is about 0.010 inch and wherein the curing temperature is about 260° F.

5 14. A method as set forth in claim 11, wherein the face sheet is cut to net shape prior to the curing step.

15. A method as set forth in claim 11, wherein a surface treatment is applied to the face sheet prior to the curing step.

10 16. A method of making an aircraft floor panel, said method comprising the steps of:

compiling a plurality of curable layers together to form a lower support level and an upper heater level,

applying a layer of a pressure sensitive adhesive to the top of the structure,

15 placing a metal face sheet on top of the pressure sensitive adhesive layer,

curing the support/heater layers, the pressure sensitive adhesive layer, and the metal face sheet at an elevated curing temperature, and

cooling the cured layers and the metal face sheet to an ambient temperature;

20 wherein the pressure sensitive adhesive layer allows the metal face sheet to expand and contract at a different thermal expansion rate than the support/heater layers during the curing and cooling steps.

17. A method as forth in claim 16, wherein the curing temperature is at least about 250° F.

18. A method as set forth in claim 17, wherein the layer of the pressure sensitive adhesive is about 0.010 inch and wherein the curing temperature is about 260° F.

19. An aircraft heated floor panel, comprising:
5 a plurality of layers cured together to form a lower support level and an upper heater level, these support/heater layers together having a certain rate of thermal expansion;

10 a face sheet for protecting the top of the panel from floor-traffic related damage, the face sheet having a different rate of thermal expansion than the underlying support/heater layers; and

an elastic adhesive bonding the face sheet to the underlying support/heater layers whereby the different rates of thermal expansion may be accommodated during curing procedures.

20. An aircraft heated floor panel as set forth in claim 19, wherein the
15 face sheet has a higher rate of thermal expansion than the underlying support/heater layers.

21. An aircraft heated floor panel as set forth in claim 20, wherein the face sheet is made of metal.

22. An aircraft heated floor panel as set forth in claim 21, wherein the
20 metal is selected from aluminum, titanium, steel, or stainless steel.

23. An aircraft heated floor panel as set forth in claim 21, wherein the elastic bonding adhesive is a pressure sensitive adhesive.

24. An aircraft heated floor panel as set forth in claim 23, wherein the pressure sensitive adhesive is an acrylic pressure sensitive adhesive.

25. An aircraft heated floor panel as set forth in claim 23, wherein the pressure sensitive adhesive is a rubber pressure sensitive adhesive.

26. A method of making the aircraft heated floor panel of claim 19, said method comprising the steps of:

- 5 applying a layer of the elastic bonding adhesive to the top of the heater level;
- placing the face sheet on top of the adhesive layer;
- curing the support/heater layers and the face sheet at an elevated curing temperature to form a composite structure; and
- 10 cooling the composite structure to an ambient temperature;
- wherein the elastic bonding adhesive layer allows the face sheet to expand and contract at a different thermal expansion rate than the support/heater layers during the curing and cooling steps.

27. A method as set forth in claim 26, wherein the face sheet is cut to net shape prior to the curing step.

28. A method as set forth in claim 26, wherein a surface treatment is applied to the face sheet prior to the curing step.

29. A method of making the aircraft heated floor panel, comprising the steps of:

- 20 compiling a plurality of curable layers together to form a lower support level and an upper heater level;
- applying a layer of an elastic bonding adhesive to the top of the structure;
- placing a face sheet on top of the adhesive layer;
- curing the support/heater layers, the adhesive layer, and the face sheet
- 25 at an elevated curing temperature to form a composite structure; and
- cooling the composite structure to an ambient temperature;

* * *

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ABSTRACT

5 An aircraft floor panel (10) comprising a plurality of layers (18) cured together to form a lower support level (20) and an upper heater level (22), and a metal face sheet (16) for protecting the underlying layers (18) from floor-traffic related damage. A pressure sensitive adhesive (32) (or other adhesive which retains elasticity after bonding) is used to bond the metal face sheet (16) to the underlying support/heater layers (18) so that the different rates of thermal expansion can be accommodated during curing and cooling steps of the manufacturing process.

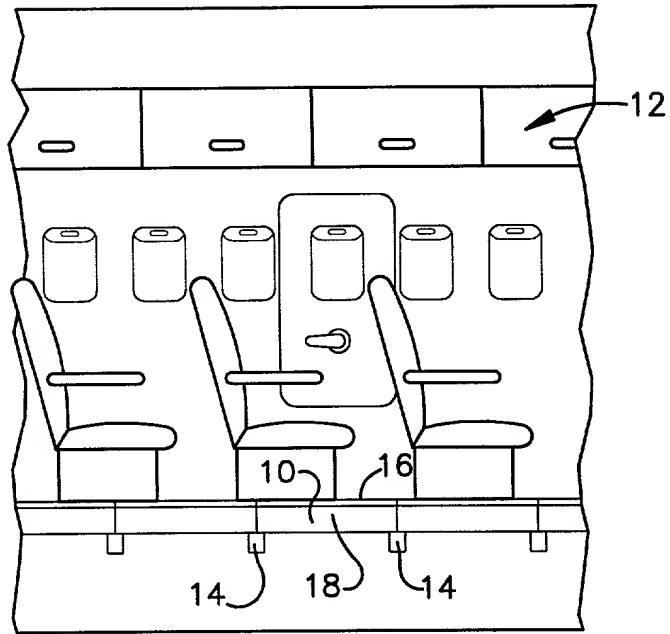


FIGURE 1

Figure 3A

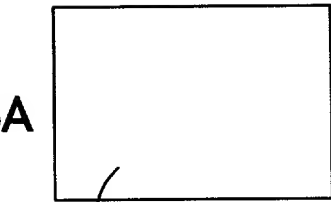


Figure 3B

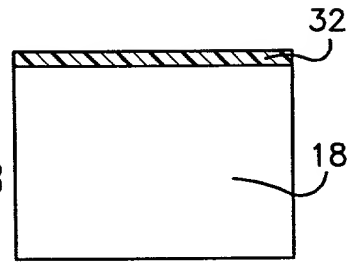


Figure 3C

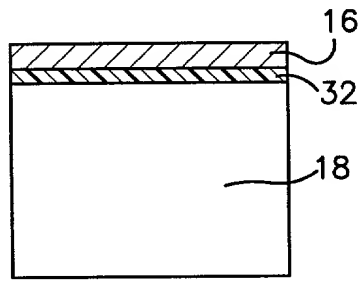


Figure 3D

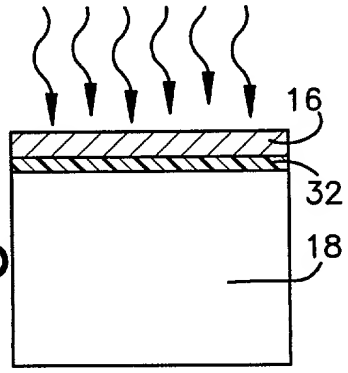


Figure 3E

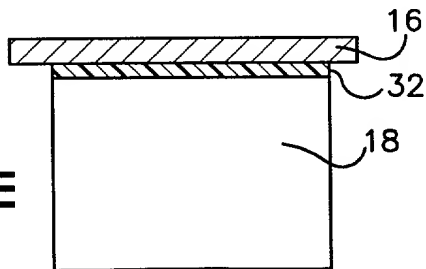


Figure 3F

